Axel MODAVE

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Professional positions

Since Oct 2016	**CNRS research scientist** *(chargé de recherche)* **ENSTA Paris** (Palaiseau, France) – Unité de Mathématique Appliquée Équipe POEMS (UMR 7231, CNRS, INRIA, Ensta Paris)
Oct 2015 → Sept 2016	**Postdoctoral Associate** at **Virginia Tech** (Blacksburg, VA, USA) Department of Mathematics *Mentor: Prof. Tim Warburton*
Oct 2014 → Sept 2015	**Postdoctoral Research Associate** at **Rice University** (Houston, TX, USA) Department of Computational and Applied Mathematics *Mentor: Prof. Tim Warburton*
Feb 2014 → June 2014	**Postdoctoral Researcher** at **Université catholique de Louvain** (Belgium) Division "Applied Mathematics and Mechanics" *Mentor: Prof. Jean-Francois Remacle*
Sept 2008 → Janv 2014	**Research and Teaching Assistant** at **Université de Liège** (Belgium) Research unit "Mathematical Modeling and Methods" (Sept 2008 → May 2010) Research unit "Applied and Computational Electromagnetics" (June 2010 → Jan 2014) *Advisors: Prof. Christophe Geuzaine and Prof. Éric Delhez*

Associate position

Since Oct 2017	**Collaborateur scientifique** at **Université de Liège** (Belgium)

Education

Sept 2008 → Oct 2013	**Doctor of Engineering Sciences** Université de Liège (Belgium)
Sept 2003 → June 2008	**Physics Engineer** with *summa cum laude* Université de Liège (Belgium)

Awards and Scholarships

- *F.R.S.-FNRS Postdoctoral Researcher* Grant (3-years post-doctoral grant - Call 2014)
- WBI Excellence Grant for 2-years research stay in the USA – 2014/2016
- BAEF Honorary Fellowship – 2014/2015

Funding

- DGA Grant (50% of a 3-years PhD funding - Call 2018) – co-P.I.
- SMAI BOUM Project Funding to organize a scientific event – April 2017
- NSF-funded Early Career Travel Award to attend *SIAM Conference on Mathematical and Computational Issues in the Geosciences* – June 2015
- SMAI Travel Grant "Jeunes chercheurs" to attend *Congrès d'Analyse Numérique* – May 2012
- Pisart Grant for Pedagogic Support – 2006/2007

Mentoring

PhD Student

- Since October 2018 – Damien Chicaud *(50%, with Patrick Ciarlet)*
  Topic: *Domain decomposition methods for solving time-harmonic electromagnetic problems in complex media*
  Funding: DGA (50%) + ENSTA Paris (50%)

Master Students

- May-July 2020 – Quentin Krempp, M1 Student at ENSTA Paris
  Topic: *Plus de science pour moins de code : Portage de codes C sur GPU avec OpenACC*
- May-August 2019 – Nassim Kesmia, M1 Student at Paris-Saclay University *(50%, with Stéphanie Chaillat)*
  Topic: *Preconditioned Boundary Element Methods for Time-Harmonic Wave Propagation*
- March-August 2018 – Damien Chicaud, M2 Student at ENSTA-ParisTech
  Topic: *DG-FEM with High-Order Absorbing Boundary Conditions for Maxwell's equations*
- March-August 2018 – María José Castellano, M2 Student at UVSQ *(50%, with Stéphanie Chaillat)*
  Topic: *A comparison of BEMs for time-harmonic wave propagation*
- May-July 2017 – Ningyuan Hu, M1 Student at ENSTA-ParisTech
  Topic: *Absorbing Boundary Conditions for the Wave Equation (Finite Differences, Corners, Stability)*

Teaching

L. = Lectures, T. = Training sessions, E. = Examination

Academic year 2020/2021

At *ENSTA Paris*, *Paris-Saclay University* and *Institut Polytechnique de Paris* (France):

- High Performance Scientific Computing – MSc
  Spring 2021 (L. 5h, T. 16h)
- Parallel Scientific Computing – MSc
  Fall 2020 (L. 9h, T. 6h, E. 6h)

Past years

At *ENSTA Paris*, *Paris-Saclay University* and *Institut Polytechnique de Paris* (France):

- High Performance Scientific Computing – MSc – Spring 2017 (L. 8h, T. 24h, E. 1h), Spring 2018 (L. 6h30, T. 14h, E. 1h), Spring 2019 (L. 7h, T. 12h), Spring 2020 (L. 8h, T. 18h) – Coordinator since Spring 2017
- Parallel Scientific Computing – MSc – Fall 2016 (T. 7h), Fall 2017 (T. 16h), Fall 2018 (L. 7h, T. 16h, E. 3h), Fall 2019 (L. 14h, T. 24h, E. 3h) – Coordinator since Fall 2018
- The Finite Element Method – MSc – Fall 2017, 2018 (T. 12h, E. 2h)
- Mathematical Models and Discretisation in Electromagnetism – MSc – Spring 2017, 2018 (L. 7h)

At *Rice University* (USA):

- Numerical Analysis 1 – Undergraduate – Fall 2014 (L. 2h)

At the *Université catholique de Louvain* (Belgium):

- Project of Structure – BSc – Spring 2014 (T. 8h)

At the *Université de Liège* (Belgium):

- Modeling and Design of Electromagnetic Systems – MSc – Fall 2013 (L. 4h)
- Multiphysic Scientific Computational Projects – MSc – Spring 2011, 2012, 2013 (T. for projets)
- High Performance Scientific Computing – MSc – Fall 2010, 2011 (T. for projets)
- Rational Mechanics – BSc – Fall 2009 (T. 30h)
- Algebra – BSc – Fall 2009 (T. 20h)
- Numerical Analysis – BSc – Fall 2007 (T. 20h)
- Continuum Mechanics – BSc – Spring 2007, 2008 (T. for projets)

Services

- Organization of scientific meetings:

  - 2020/11: Co-organization of *Young Researchers' Days* on *"Numerical Methods for Time-Harmonic Wave Propagation Solvers"* (2 days, approx. 40 participants) with Marcella Bonazzoli (INRIA), Théophile Chaumont-Frelet (INRIA) and Bertrand Thierry (CNRS). (website)
  - 2018/07: Co-organization of a mini-symposium on *"Accurate and Fast Numerical Solvers for Large-scale Wave Propagation Problems"* at WCCM 2018, with S. Chaillat (CNRS, POEMS, France), J. Chan (Rice, USA) and A. Gillman (Rice, USA).
  - 2017/10: Co-organization of *Young Researchers' Days* on *"Large-Scale Wave Propagation Solvers"* (2 days, 20 participants) with Bertrand Thierry (CNRS, LJLL, France). (website)
  - 2013/05: Co-organization of the 2^{nd} Gmsh Workshop (2 days, 50 participants)
- Reviewer for *Applied Mathematics and Computation*, *Advanced Electromagnetics*, *Computers and Mathematics with Applications*, *Geophysical Journal International*, *International Journal of Numerical Modelling (Electronic Networks, Devices and Fields)*, *Journal of Computational and Applied Mathematics*, *Journal of Computational Physics*, *SIAM journal on numerical analysis* and *SIAM journal on scientific computing*.
- Involvement in academic bodies of the University of Liège (Oct 2005 → Sept 2013) (faculty council, department council and bachelor/master councils)

Software

- Developer of testing codes to evaluate implementation strategies for accelerated wave propagation with continuous and discontinuous finite element schemes.
- Co-developer (2014-2015, leader) of an industrial software *(RiDG)* for accelerated seismic imaging on GPU/CPU clusters, discontinuous finite element schemes, C++ code with OCCA (CUDA, OpenCL and OpenMP) and MPI
- Co-developer (2010-2014) of an academic software *(Gmsh/dg)* for time-domain wave propagation on CPU clusters, discontinuous finite element schemes, C++ code with MPI
- Advanced user (since 2010) of the open-source softwares Gmsh *(mesh generator with pre- and post-processing facilities)*, GetDP *(finite element solver)* and Onelab *(user-friendly interface)*.

List of publications and communications

Preprints

[1] D. Chicaud, P. Ciarlet, A. M. (2020). Analysis of variational formulations and low-regularity solutions for time-harmonic electromagnetic problems in complex anisotropic media. Submitted, 24 pages [preprint]

Papers in international journals

[15] H. Beriot, A. M. (2020). An automatic PML for acoustic finite element simulations in convex domains of general shape. *International Journal for Numerical Methods in Engineering*, In press, 24 pages [link] [preprint]

[14] A. M., A. Royer, X. Antoine, X. Geuzaine (2020). A non-overlapping domain decomposition method with high-order transmission conditions and cross-point treatment for Helmholtz problems. *Computer Methods in Applied Mechanics and Engineering*, 368, 113162, 23 pages [link] [preprint] **[codes]**

[13] A. M., X. Geuzaine, X. Antoine (2020). Corner treatments for high-order absorbing boundary conditions in high-frequency acoustic scattering problems. *Journal of Computational Physics*, 401, 109029, 24 pages [link] [preprint] **[codes]**

[12] A. M., A. Atle, J. Chan, T. Warburton (2017). High-order absorbing boundary conditions with corner/edge compatibility for GPU-accelerated discontinuous Galerkin wave simulations. *International Journal of Numerical Methods in Engineering*, 112 (11), 1659-1686, 28 pages [link] [preprint]

[11] A. M., J. Lambrechts, C. Geuzaine (2017). Perfectly Matched Layers for Convex Truncated Domains with Discontinuous Galerkin Finite Element Simulations. *Computers and Mathematics with Applications*, 73 (4), 684-700, 17 pages [link] [preprint] **[movies]**

[10] J. Chan, Z. Wang, A. M., J.-F. Remacle, T. Warburton (2016). GPU-accelerated discontinuous Galerkin methods on hybrid meshes. *Journal of Computational Physics*, 318, 142-168, 27 pages [link] [preprint]

[9] A. M., A. St-Cyr, T. Warburton (2016). GPU performance analysis of a nodal discontinuous Galerkin method for acoustic and elastic models. *Computers & Geosciences*, 91, 64-76, 13 pages [link] [preprint]

[8] A. M., A. St-Cyr, W. A. Mulder, T. Warburton (2015). A nodal discontinuous Galerkin simulations for reverse-time migration on GPU clusters. *Geophysical Journal International*, 203 (2), 1419-1435, 17 pages [link] [preprint]

[7] A. M., E. Delhez, C. Geuzaine (2014). Optimizing Perfectly Matched Layers in Discrete Contexts. *International Journal of Numerical Methods in Engineering*, 99 (6), 410-437, 28 pages [link] [preprint]

[6] M. Boubekeur, A. Kameni, L. Pichon, A. M., C. Geuzaine (2014). Analysis of transient scattering problems using a discontinuous Galerkin method: application to the shielding effectiveness of enclosures with heterogeneous walls. *International Journal of Numerical Modelling: Electronic Networks, Devices and Fields*, 27 (3), 626-635, 10 pages [link] [preprint]

[5] M. Boubekeur, A. Kameni, L. Bernard, A. M., L. Pichon (2014). 3-D Modeling of Thin Sheets in the Discontinuous Galerkin Method for Transient Scattering Analysis. *IEEE Transactions on Magnetics*, 50 (2), 4 pages [link] [preprint]

[4] M. Boubekeur, A. Kameni, A. M., L. Bernard, L. Pichon (2013). Modeling of Weakly Conducting Thin Sheets in the Discontinuous Galerkin Method for Shielding Effectiveness Evaluation. *ACES Journal*, 28 (10), 7 pages [link] [preprint]

[3] A. M., A. Kameni, J. Lambrechts, E. Delhez, L. Pichon. C. Geuzaine (2013). An optimum PML for scattering problems in the time domain. *The European Physical Journal - Applied Physics*, 64 (2), 6 pages [link] [preprint]

[2] A. Kameni, A. M., M. Boubekeur, V. Preault, L. Pichon, C. Geuzaine (2013). Evaluation of shielding effectiveness of composite wall with a Time Domain Discontinuous Galerkin Method. *The European Physical Journal - Applied Physics*, 64 (2), 4 pages [link] [preprint]

[1] A. M., E. Deleersnijder, E. Delhez (2010). On the parameters of absorbing layers for shallow water models. *Ocean Dynamics*, 60 (1), 65-79, 15 pages [link] [preprint]

Theses

[2] *"Absorbing Layers for Wave-Like Time-Dependent Problems – Design, Discretization and Optimization"*
PhD thesis, Université de Liège, Belgique, Octobre 2013
Advisors: Prof. Christophe Geuzaine and Prof. Éric Delhez

[1] *"Étude de modèles de frontière ouverte pour des problèmes de propagation d'ondes"* (in french)
Master thesis, Université de Liège, Belgique, Juin 2008
Advisor: Prof. Éric Delhez

International conferences *(first name in the list of authors = speaker)*

[27] A. M., X. Antoine, A. Royer, C. Geuzaine A non-overlapping domain decomposition method with high-order transmission conditions and cross-point treatment for Helmholtz problems. Talk at the *WCCM-ECCOMAS congress* – On line – January 11-15, 2021

[26] A. Royer, A. M., E. Béchet, C. Geuzaine A non-overlapping domain decomposition method with perfectly matched layer transmission conditions. Talk at the *26th International Domain Decomposition Conference* (DD26) – On line – December 7-12, 2020

[25] A. M., X. Antoine, A. Royer, C. Geuzaine A non-overlapping domain decomposition method with high-order transmission conditions and crosspoint treatment for Helmholtz problems. Talk at the *26th International Domain Decomposition Conference* (DD26) – On line – December 7-12, 2020

[24] R. Dai, A. M., J.-F. Remacle, C. Geuzaine Parallel sweeping preconditioners for rectangular domain decompositions with cross points applied to the Helmholtz equation . Talk at the *26th International Domain Decomposition Conference* (DD26) – On line – December 7-12, 2020

[23] A. M. An efficient domain decomposition method with cross-point treatment for Helmholtz problems. Talk at the *CIRM conference on "Parallel Solution Methods for Systems Arising from PDEs"* – Marseille (France) – September 16-20, 2019

[22] A. M., X. Antoine, A. Royer, C. Geuzaine. An Efficient Domain Decomposition Method with Cross-point Treatment for Helmholtz Problems. Talk in a minisymposium at the *14th International Conference on Mathematical and Numerical Aspects of Waves Propagation* (WAVES 2019) – Vienna (Austria) – August 25-30, 2019 – 2-pages paper

[21] D. Chicaud, P. Ciarlet, A. M.. Perturbed edge finite element method for the simulation of electromagnetic waves in magnetised plasmas. Talk at the *14th International Conference on Mathematical and Numerical Aspects of Waves Propagation* (WAVES 2019) – Vienna (Austria) – August 25-30, 2019 – 2-pages paper

[20] A. M., X. Antoine, C. Geuzaine. An Efficient Domain Decomposition Method with Cross-point Treatment for Helmholtz Problems. Talk in a minisymposium at the *SIAM Conference on Computational Science and Engineering* (CSE19) – Spokane (Washington, USA) – February 25-March 1, 2019

[19] A. M., X. Antoine, C. Geuzaine. An efficient DDM with cross-point treatment for Helmholtz problems. Talk in a minisymposium at the *XXXIX Ibero-Latin American Congress on Computational Methods in Engineering* (CILAMCE 2018) – Paris/Compiègne (France) – November 11-14, 2018 – 4-pages paper

[18] A. M., X. Antoine, C. Geuzaine. An Efficient DDM with Cross-points for the Parallel Finite Element Solution of Helmholtz Problems. Talk in a minisymposium at the *13th World Congress on Computational Mechanics* (WCCM 2018) – New York City (NY, USA) – July 22-27, 2018

[17] A. M., V. Mattessi, C. Geuzaine. High-order absorbing boundary conditions with edge and corner compatibility for the Helmholtz equation. Talk in a minisymposium at the *7th International Conference on Advanced Computational Methods in Engineering* (ACOMEN 2017) – Ghent (Belgium) – September 18-22, 2017 – 2-pages paper

[16] A. M., A. Atle, J. Chan, T. Warburton. A nodal discontinuous Galerkin method with high-order absorbing boundary conditions and corner/edge compatibility. Talk at the *13th International Conference on Mathematical and Numerical Aspects of Waves Propagation* (WAVES 2017) – Minneapolis (USA) – May 15-19, 2017 – 2-pages paper

[15] A. M., A. Atle, J. Chan, R. Hewett, T. Warburton. High-Order Absorbing Boundary Conditions for Time-Domain Wave Propagation with DG Methods. Talk in a minisymposium at the *SIAM Conference on Computational Science and Engineering* (CSE17) – Atlanta (Georgia, USA) – February 27-March 3, 2017

[14] A. M., J. Chan, T. Warburton. GPU Performance Analysis of Discontinuous Galerkin Implementations for Time-Domain Seismic Wave Propagation. **Talk in a HPC dedicated session** at the *78th EAGE Conference & Exhibition* – Vienna (Austria) – May 30-June 2, 2016

[13] A. M., J. Chan, T. Warburton. GPU Performance Analysis of Discontinuous Galerkin Implementations for Time-Domain Wave Simulations. Talk at the *17th SIAM Conference on Parallel Processing for Scientific Computing* (PP16) – Paris (France) – April 12-15, 2016

[12] A. M., A. St-Cyr, T. Warburton. Performance of DGTD Finite Element Methods for the RTM Procedure on GPU Clusters. Talk at the *2016 Oil & Gas HPC Conference* – Houston (Texas, USA) – March 2-3, 2016

[11] A. M., A. St-Cyr, T. Warburton, W. A. Mulder. Accelerated Discontinuous Galerkin Time-Domain Simulations for Seismic Imaging. Talk in a minisymposium at the *SIAM Conference on Mathematical & Computational Issues in the Geosciences* (GS15) – Stanford (California, USA) – June 29-July 2, 2015

[10] A. M., A. St-Cyr, T. Warburton, W. A. Mulder. Accelerated Discontinuous Galerkin Time-Domain Simulations for Seismic Wave Propagation. **Talk in a HPC dedicated session** at the *77th EAGE Conference & Exhibition* – Madrid (Spain) – June 1-4, 2015

[9] A. M., D. Medina, A. St-Cyr, T. Warburton. RiDG: A Portable High-Performance Simulation Tool for Seismic Imaging. Talk at the *2015 Oil & Gas HPC Workshop* – Houston (Texas, USA) – March 4-5, 2015

[8] M. Boubekeur, A. Kameni, L. Bernard, A. M., L. Pichon (2013). 3D Modeling of Thin Resistive Sheets in the Discontinuous Galerkin Method for Transient Scattering Analysis. Poster at the *19th Conference on the Computation of Electromagnetic Fields* (COMPUMAG 2013) – Budapest (Hungary) – 30 June-4 July, 2013 – 2-pages paper

[7] A. M., J. Lambrechts, E. Delhez, C. Geuzaine. A PML for convex truncated domains in time-dependent acoustics with a DG-FE discretization. Talk at the *11th International Conference on Mathematical and Numerical Aspects of Waves Propagation* (WAVES 2013) – Gammarth (Tunisia) – June 3-7, 2013 – 2-pages paper

[6] A. M., C. Geuzaine, M. Boubekeur, L. Pichon, A. Kameni. Evaluation of Shielding Effectiveness in the Time Domain using a DG Method with an Efficient PML. Poster at the *9th International Symposium on Electric and Magnetic Fields* (EMF 2013) – Bruges (Belgium) – April 23-25, 2013

[5] A. M., E. Delhez, A. Kameni, L. Pichon, C. Geuzaine. An optimum PML for scattering problems in the time domain. Talk at the *7e Conférence Européenne sur les Méthodes Numériques en Electromagnétisme* (NUMELEC 2012) – Marseilles (France) – July 3-5, 2012 – 2-pages paper

[4] A. Kameni, A. M., M. Boubekeur, C. Geuzaine, L. Pichon. Évaluation de l'efficacité de blindage de parois hétérogènes par une méthode de Galerkin discontinue en domaine temporel. Poster at the *7th European Conference on Numerical Methods in Electromagnetism* (NUMELEC 2012) – Marseilles (France) – July 3-5, 2012 – 2-pages paper

[3] A. M., E. Delhez, C. Geuzaine. On the Parameters of the Perfectly Matched Layer in Discrete Contexts. Talk at the *10th International Conference on Mathematical and Numerical Aspects of Waves Propagation* (WAVES 2011) – Vancouver (Canada) – July 25-29, 2011 – 4-pages paper

[2] A. M., E. Delhez, C. Geuzaine. Optimization of the PML in the Discrete Context for Wave-Like Problems. Talk at the *7th International Congress on Industrial and Applied Mathematics* (ICIAM 2011) – Vancouver (Canada) – July 18-22, 2011

[1] A. M., E. Deleersnijder, E. Delhez. Absorbing layers for shallow water models. Talk at the *15th Biennal Workshop of the Joint Numerical Sea Modelling Group* (JONSMOD 2010) – Delft (The Netherlands) – May 12-10, 2010

National conferences

[5] A. M., X. Antoine, C. Geuzaine. An efficient domain decomposition method with cross-point treatment for Helmholtz problems . Talk at the *14ème Colloque National en Calcul des Structures* (CSMA 2019) – Giens (France) – May 13-17, 2019

[4] A. M., X. Antoine, C. Geuzaine. Conditions aux limites absorbantes d'ordre élevé pour l'équation de Helmholtz : traitement des coins et application en DDM. Talk in a minisymposium at the *44e Congrès National d'Analyse Numérique* (CANUM 2018) – Cap d'Agde (France) – May 28-June 1, 2018

[3] A. M. An efficient DDM with cross-points for the parallel finite element solution of Helmholtz problems. **Invited talk** and poster at the *Journées "Advanced Theoretical and Numerical Methods for waves in structured Media"* organized by the thematic group *"Modélisation et simulation"* (GT1) of GDR Ondes – Paris (France) – March 13-14, 2018

[2] A. M., E. Delhez, C. Geuzaine. Optimisation des PML dans des contextes discrets. Talk at the *41e Congrès National d'Analyse Numérique* (CANUM 2012) – Superbesse (France) – May 21-25, 2012

[1] A. M. Optimizing the PML in the discrete context. **Invited talk** at the *Journées de Metz 2012 "Recent Advances in Modeling, Analysis and Simulation of Wave Propagation"* – Metz (France) – March 29-31, 2012

Seminars and others talks

17. Invited talk at the meeting day of the teams DEFI, MEDISIM and POEMS – Palaiseau (France) – December 18, 2019
16. Seminar at the *Laboratoire de mécanique et d'acoustique* (LMA) – Marseilles (France) – July 16, 2019
15. Seminar of applied analysis at the *Laboratoire Amiénois de mathématique fondamentale et appliquée* (LAMFA) – Amiens (France) – April 29, 2019
14. Seminar of numerical analysis at the *Institut de recherche mathématique de Rennes* (IRMAR) – Rennes (France) – June 15, 2017
13. Colloquium at *VirginiaTech*, department of mathematics – Blacksburg (Virginia, USA) – March 25, 2016
12. Industrial seminar at *TOTAL E&P* – Houston (Texas, USA) – January 21, 2016
11. Seminar of the research team MAGIQUE-3D (INRIA) – Pau (France) – January 5, 2016
10. Seminar of the research team POEMS (CNRS, INRIA, ENSTA) – Palaiseau (France) – December 17, 2015
9. Seminar of numerical methods at the *Laboratoire Jacques-Louis Lions* (LJLL), UPMC – Paris (France) – December 14, 2015
8. Seminar at *VirginiaTech*, SIAM Student Chapter – Blacksburg (Virginia, USA) – November 19, 2015
7. Industrial seminar at *Shell Technology Center* – Rijswijk (The Netherlands) – June 9, 2015
6. Seminar of the graduate students in mathematics at SMU – Dallas (Texas, USA) – April 14, 2015
5. Seminar at *University of A Coruña*, SINUMAR – A Coruña (Spain) – July 17, 2014
4. Seminar at research team NACHOS (INRIA) – Sophia-Antipolis (France) – June 3, 2014
3. Seminar at *Université catholique de Louvain* (UCL) – Louvain-la-Neuve (Belgium) – February 10, 2014
2. Invited talk at 1st Gmsh Workshop – Braives (Belgium) – September 15-16, 2011
1. Invited talk at ANR MicroWave – Nancy (France) – December 2-3, 2010